Estonian mires

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Abstract: In Estonia altogether 1.626 peatlands with an area over 10 ha are recorded, 143 mires extend over more than 1.000 ha. Mires occur all across the country but the species-rich fen areas are situated mainly on Saaremaa Island and in the western part of the Estonian mainland, mixotrophic bogs are found first of all in western and central Estonia, larger raised bogs are located in the southwestern, northeastern and central parts. The flora of vascular plants of Estonian natural mires includes 280 species; from these 230 occur in fens, 103 in transitional mires and 45 species in raised bogs, respectively. Among the Estonian mires five habitat site types and 11 subtypes have been established. Due to their species richness the most conspicuous mires on the North European scale are calcareous fens and spring fens.

By 1980 about 1,006.300 ha of lands were ameliorated. Peat is one of the most important natural resources for Estonia; the yearly production in 1970-1990 reached about 2.5×10^6 tons (with 40% water content). In the recent years the amount of annual peat excavation has been $1.2\text{-}1.5 \times 10^6$ tons that exceeds the natural peat accumulation rate two–three times. Moreover, comparing the annual emission range ($0.8\text{–}1.6 \times 10^6$ tons of CO_2-C) with the possible total annual carbon storing by peat accumulation ($0.25\text{–}0.32 \times 10^6$ t CO_2-C), it follows that the emission from drained fen sites alone is on the average four times higher than its total annual carbon accumulation. Adding the areas drained for forestry and industry purposes, we may reckon with up to 8–10 times higher emissions.

Nearly natural conditions (in at least $^2/_3$ part of a mire) have still been preserved in some 200 mires covering a total area of about 310.000 ha. More than 100.000 ha of areas with mire vegetation are protected in Estonia by now, over $^3/_4$ of which are ombrotrophic areas. Actual problems in wise usage of the Estonian mires are (1) overexploitation of peat resources, (2) increasing commercial pressure, (3) insufficient rehabilitation of spoiled areas, (4) industrial pollution, (5) fires, (6) long-term drainage effects, (7) evolvement of protected mires network.

Key words: biodiversity, classification, drainage, excavation, human impaxt, rehabilitation.

Nomenclature: LAASIMER et al. (1993), INGERPUU et al. (1994), KUUSK et al. (1996, 2003).

General features of Estonian nature

Landforms and soils

Although the territory of Estonia covers only 47.450 km^2, its landscapes are of a varied and original character. The topography has developed its contemporary form as a result of the erasing and accumulating action of the continental ice sheet and the subsequent postglacial transgressions of the Baltic Sea. Estonia was freed from the glacier 13.500 –11.000 years ago (RAUKAS 1986). The crystalline basement lies deeper than 110 meters and so has no influence on recent landforms. The bedrock in North, East and Central Estonia consists mainly of Ordovician and Silurian carbonate limestones, marls and dolomites, whereas South Estonia is the region of Devonian sandstones and locally of carbonate rocks. Moraines attain a more significant thickness (up to 200 m) in South Estonia.

Orographically Estonia is a section of the East European Plain, being situated only 0 to 317 m above sea level. The territory can be divided into two parts – Lower Estonia and Upper Estonia. The former was, following the retreat of the ice, inundated by the sea for a considerably longer time than Upper Estonia (VAREP 1968).

The western part of the country, including numerous islands and bays, and the big lake depressions in the eastern part belong

Photo 1: Ridge-hollow-pool subtype ombrotrophic bog. Põltsamaa bog, Alam-Pedja Nature Reserve.

to Lower Estonia. The limestone bedrock of the West Estonian islands and of the West Estonian Lowland is mostly covered by thin calcareous soils overgrown with juniper, while forest areas, bogs, fens and marshes are also represented. The depressions of Lake Peipsi and Lake Võrtsjärv are covered by extensive floodplain meadows, wetlands, and forests.

The landscapes of Upper Estonia are more diverse, the moraine cover is thick, the soil more fertile, and the human population denser when compared with that of Lower Estonia. The uplands and heights are intersected by a number of river valleys with outcrops of Devonian red sandstone on high river banks.

Calcareous (rendzina) and peat soils predominate in North, Central and West Estonia. In South Estonia podzols, peaty podzols and peat soils on tills and sands are widespread. The most fertile sandy clayey soils, related to brown soils, occur on yellowish-gray calcareous tills (REINTAM 1995).

Climate

Estonia is situated climatically in the mixed forest subdistrict of the temperate zone. It is characterized by warm summers and by moderately mild winters. The vegetation period with average twenty-four-hour air temperatures above +5°C lasts 165-185 days; the period with average air temperature above +10°C lasts 110-135 days. The climate is humid, especially in coastal regions. The mean annual amount of precipitation is highest in South Estonia and in the area of the Pandivere Upland (up to 700 mm per year), and lowest on the large islands of the Baltic Sea (about 550 mm) (EESTI NSV KLIIMAATLAS 1969). Since the annual precipitation exceeds evaporation roughly twofold, the climate is excessively damp.

Vegetation

The vegetation of Estonia is rather diverse. Forests, mires and grasslands alternate with cultivated land. Forests make up 44-47% of the territory, including about 7% of coppices and brushwood (ETVERK & SEIN 1995), grasslands up to 20% (PETERSON 1994). Peatlands with peat deposits thicker than 30 cm cover approximately 21.5% of the territory. If water-logged areas with peat deposits less than 30 cm are included, 31% of Estonia could be considered to be covered by peat or peaty soils (VALK 1988). Thus, by the proportion of territory paludification Estonia has the second place in the northern Europe after Finland (ALLIKVEE & ILOMETS 1995).

Geobotanically, Estonia belongs to the boreo-nemoral vegetation zone, as does Latvia, the northern part of Lithuania, the adjacent part of European Russia, the southernmost part of Finland, a broad belt across Sweden and the southern part of Norway (MOEN 1999). In forests tree canopy Norway spruce (*Picea abies*), silver birch (*Betula pendula*) and Scotch pine (*Pinus sylvestris*) are the dominating species, to a lesser extent also small leaved lime (*Tilia cordata*), pedunculate oak (*Quercus robur*), common ash (*Fraxinus excelsior*) and European aspen (*Populus tremula*) are represented.

Black alder (*Alnus glutinosa*) and downy birch (*Betula pubescens*), rarely spruce, dominate in the canopy layer of swamp forests in which *Crepis paludosa*, *Thelypteris palustris*, *Calla palustris*, *Cirsium oleraceum*, *Filipendula ulmaria* etc. are characteristic of the herb layer. Birch, aspen and grey alder (*Alnus incana*) forests are, as a rule, secondary in Estonia, replacing other forest types after clearcutting or covering abandoned fields and grasslands.

Grasslands have appeared in Estonia as a consequence of the felling of forests and subsequent continuous mowing or pasturing. Paludified grasslands (with a peat layer less than 30 cm) on calcium-poor tills are characterized by communities of *Carex nigra* and *C. panicea*, *Deschampsia cespitosa*, and *Nardus stricta*. They have evolved mostly from swampy birch forests. Fens and wet meadows, particularly rich in plant species, are found on calcareous tills or bedrock. For these habitats typical communities are such as Primulo–Seslerietum, Caricetum hostianae and Caricetum davallianae (PAAL 1997).

Mire biodiversity

Levels of biodiversity

The most prevalent usage of the term 'biodiversity' is a synonym for 'variety of life' (GASTON 1996). The multiple dimensions and levels at which this variety, diversity or heterogeneity can be observed has often been emphasized. The Convention on Biological Diversity (GLOWKA et al. 1994) declares that "'biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

Thus, in contemporary ecology and its applications the subject under investigation is more and more differentiated, making it reasonable to deal with the biodiversity of nature on different levels and to use adequate classification approaches for it. In studies of mire biodiversity six basic levels can be differentiated according to the scale and objects under investigation (MASING & PAAL 1998, MASING et al. 2000). Tab. 1 presents these levels in mires biodiversity research together with corresponding examples from Estonian mire studies.

Species diversity

The fist attempts to analyse the total number of species characteristic to the Estonian mires were undertaken in the 1980's. It was estimated that in mires grow 35 bryophyte species of *Marchantiopsida*, 118

Photo 2: *Selaginella selaginoides* is growing mainly in calcareous fens in northeastern and northern Estonia.

Tab. 1: Levels and subjects in mires biodiversity study and Estonian literature references *where they are discussed.*

Levels and * subjects under investigation	Classification approaches and units	References
Population level * clone development * reproduction strategies	population structure and types	MASING 1982, REIER 1982
Species level		
* species of plants, fungi and animals	traditional taxonomical units and types of their geographical ranges	TRASS 1960, 1994, JÄRVA & PARMASTO 1980, KALA MEES & RAITVIIR 1982, LAASIMER et al. 1993, INGERPUU et al. 1994, LEIBAK et al. 1994, KUUSK et al. 1996, 2003, VIIDALEPP & REMM 1996
* life and growth forms	life form classification	BOTCH & MASING 1983
* consortia, guilds, synusia	ecological groups with certain status in food chains and other relationships	MASING 1981, PAAL 1994, REIER 1995
Coenotic level * plant communities (phytocoenoses)	syntaxonomical units	LIPPMAA 1933, TRASS 1958, 1994, LAASIMER 1965, MASING 1982, 1984, MASING & PAAL 1998
* fungal communities (mycocoenoses)		KALAMEES 1982
* animal communities as parts of biotic communities (biocoenoses)		HABERMAN 1959, LILLELEHT 1998, MASING et al. 2000
Ecosystem level * biotopes, ecotopes, habitats, sites	habitat or site types, mire types, forest types	MASING 1975, LÕHMUS 1984, PAAL 1997
Landscape level		
* mire complexes	landscape units, mire typology (s.l.)	AAVIKSOO et al. 1997, 2000, MASING 1972, 1974, 1982, 1984
Regional level * mire provinces and zones	regional units	THOMSON 1924, BOTCH & MASING 1983, VALK 1988

Photo 3: Treed fen in early spring. Alam-Pedja Nature Reserve.

Photo 4: Quacking fens are often surrounding lakes. Latsejärve Lake, Karula National Park.

species of *Bryopsida*, among them 35 *Sphagnum* spp. (KANNUKENE & KASK 1982). From vascular plants are represented 18 species of *Pteridophyta*, 3 species of *Gymnospermae* and 355 species of *Angiospermae* (KASK 1982). Moreover, in mires occur more than 300 species of *Aranei* (VILBASTE 1980, 1981), more than 1600 species of *Insecta*, 4 species of *Amphibia*, 3 species of *Reptilia*, more than 200 species of *Aves*, 11 species of *Mammalia* (MAAVARA 1988)

Still, TRASS (1994) has pointed out that this compendiums do not help very much in understanding mire flora because the authors do not define what is a "true" mire plant, and the typology of mire plants is lacking in cited publications. According to his analysis, the flora of vascular plants of Estonian natural mires includes 280 species; from these 230 occur in fens, 103 in transitional mires and 45 species in raised bogs, respectively. 52% of the 280 species are facultative, 36% obligate-facultative and only 12% obligate telmatophytes, which demonstrates the very low specific character of the mire flora.

Typological diversity

Result of communities, habitats, ecosystems or landscapes diversity assessment depends directly on the applied classification systems; the same objects can be classified by different parameters and from different aspects. Therefore, it is necessary to characterize briefly the main approaches used for Estonian mire classification.

I. The most popular classification of mires has been derived from C. WEBER'S (1908) fundamental division and is based on the developmental stage and trophic conditions as follows:

- Eutrophic mires, rich in nutrients, low-lying in depressions (Niedermoore, Niederungsmoore in German),
- Mesotrophic or transitional mires (Übergangsmoore),

Photo 5: Spring fen in early spring. Võllingu spring, Endla Nature Reserve.

- Oligotrophic mires, poor in nutrients and mostly situated "high" in watershed areas (Hochmoore), named also bogs. This division was adapted to Estonian conditions using also vegetation characters (MASING 1975; Tab. 2).

II. When hydrological characteristics were recognized as the main factor for mire formation, a classification based on the hydrochemical conditions and water sources was introduced. Following this approach, Estonian mires were classified (MASING 1975, ILOMETS & KALLAS 1995) as :

- Minerotrophic mires, supplied by various water sources;
- Soligenous, supplied by springs,
- Topogenous, supplied by normal ground water,
- Limnogenous, supplied by floods or forming through the overgrowing of waterbodies,
- Ombrotrophic mires, supplied by rain water only.

The same principle has been widely used in Scandinavian and other Baltic countries, in Russia and Germany.

III. In the course of vegetation mapping, geobotanical studies and aerial surveys of mires, the prevailing vegetation layer has been found to be the best suitable basis for mire classification (AAVIKSOO et al. 1997, 2000, MASING et al. 2000):

- Forests on peatland (swamp forest, carr, Moorwald, Bruch etc.) – with a continuous tree layer,
- Wooded peatlands with sparse trees,
- Shrub peatlands with dominating *Salix* spp., *Myrica gale* etc.,
- Dwarf-shrub peatlands with dominating *Calluna vulgaris*, *Ledum palustre*, *Vaccinium uliginosum* etc.,
- Grass-covered peatlands with *Carex* spp., *Trichophorum* spp. and *Eriophorum* spp.,
- Moss-rich peatlands with prevailing *Sphagnum* spp. cover.

IV. Defining in nature homogeneous areas representing a comparatively steady complex of ecological conditions is always disputable and depends on the spatial or temporal scale considered. Still, one of the most striking physiognomic features of raised bogs is their mosaicness or patchiness, especially well determinable from air. This mosaicness has often rather regular concentric, eccentric, or striped structure, and is closely associated with the partition of bog surface into areas of different ecological quality. Thus, it seems logical to establish the bogs classification just on the basis of these quite easily distingushable morphological components (MASING 1975, MASING et al. 2000). It has already been done so in the

Tab. 2: Differences in mires due to trophic conditions (after LAASIMER & MASING 1995).

Characters	Eutrophic	Mesotrophic	Oligotrophic
Water supply and trophic states	precipitation, ground, surface and flood water	precipitation, little influence of ground water	precipitation water only
Land form of the mire as a whole	flat or concave	flat	convex or flat
Microtopography	even or with grass (sedge) tussocks	cotton-grass tussocks and moss hummocks	a mosaic of moss hummocks and depressions
Tree layer	*Betula pubescens*, *Alnus glutinosa*, sparse *Picea abies*, seldom *Pinus sylvestris*	*Betula pubescens* and *Pinus sylvestris* only	*Pinus sylvestris* only, or/and sparse *Betula pubescens*
Shrub layer	*Betula humilis*, *Myrica gale*, *Salix* ssp.	*Myrica gale*, sparse *Salix* ssp.	absent
Dwarf shrub layer	absent	*Calluna vulgaris*, *Ledum palustre*, *Andromeda polifolia*, *Chamaedaphne calyculata*, *Vaccinium uliginosum* on hummocks	
Grass and herb layer (field layer)	various grasses, herbs and forbs, especially *Carex* ssp.	in depressions eutrophic plants, often *Comarum palustre*, *Menyanthes trifoliata*, *Trichophorum alpinum*, *Carex lasiocarpa*	*Eriophorum vaginatum*, *Trichophorum cespitosum*, *Rhynchospora alba*, *Rubus chamaemorus* and *Drosera* ssp.
Moss layer	mainly *Bryales*	mainly *Sphagnales*, often *Polytrichum strictum*, *Aulacomnium palustre*	
Peat	mainly sedge or woody peat suitable for fuel and fertilising	mainly sedge peat suitable for fuel and litter	only sphagnum peat suitable for litter and gardening

Photo 6: Spring fen in early spring. Oostriku spring, Endla Nature Reserve.

Photo 7: Bog forest. Meenikunno bog, Põlvamaa district.

Photo 8: Mock-hollow subtype ombrotrophic bog. Tolkuse bog, Pärnumaa district.

course of almost a century by numerous mire researchers and usually the scope and ranking of bog components by various authors has been remarkably overlapping, only the terminology differs.

According to the proposal of IMCG Workshop on Global Mire Classification, Greifswald, March 1998, the elementary components of mire landscapes or ecosystems, (1) corresponding to the spatial scale 10^{-1}–10^{1} m^2, (2) having a relative homogeneous vegetation or a homogeneous small-scale mosaic of that and, (3) having a certain quality of abiotic conditions, should to be called a 'nanotope'. Earlier they were named as bog features (SJÖRS 1948), microforms (MASING 1982) etc. It is commonly recognized that the main nanotopes of raised bogs are hummocks or hummock ridges, hollows and pools. In addition, funnels, rivulets and pool islands having usually a comparatively limited area can be also delineated here (MASING 1975, MASING et al. 2000). It is also well known, that on the nanotope level a good correlation exists between the vegetation, water level, water infiltration, flow and evaporation, pH, redox potential, decomposition rate of the plant litter etc. (e.g. SJÖRS 1950, IVANOV 1981, LINDSAY et al. 1985, MALMER 1985, JENÍK & SOUKUPOVÁ 1992, KAROFELD 1999). Thus, a classification system of nanotopes will largely be at once a classification of environmental conditions as well as of vegetation. Of course, the hierarchical classification of nanotopes cannot totally satisfy the demands of hydrologic or vegetation classification, so as the nanotopes are distinguished in a quite a rough manner and are not so numerous as the plant communities, or they will not reflect all the initimate peculiarities of water and nutrient conditions. For that purpose special classifications are needed.

On a larger spatial scale (10^4–10^6 m^2) the nanotopes form the next hierarchical level of bog structure, 'microtope', either combining mutually or alone (if they occupy a larger area); earlier synonyms: complex – OSVALD 1923; microlandscape – GALKINA 1946; site – SJÖRS 1948, facies – LOPATIN 1954 etc.). The microtopes constitute on the spatial scale 10^5–10^7 m^2 a bog, or mesotope (synonyms: mesolandscape – GALKINA 1946; complex – SJÖRS 1948; urochishche – LOPATIN 1954 etc.).

However, it seems that the spatial scale limits of microtopes need a correction at least for two reasons. First, in the discussed system the scale from 10^1 to 10^4 m^2 is not covered at all and, second, the lower limit for microtopes – 10^4 m^2 – is obviously too large. In nature (e.g. in southern Estonia hilly landscape) we can find numerous raised bogs (mesotopes) having a size about 1 ha (i.e. 10^4 m^2) or even less and being made up of numerous microtopes. Therefore, according to my experience, the lower limit of the microtope spatial scale should

be diminished up to the upper limit of nanotopes and, correspondingly, the corrected spatial scale for microtopes would be 10^1–10^6 m^2.

Traditionally, raised bogs are classified according to (1) whether there does exist a tree layer or not (open bog expanse, treed bog, bog forest), (2) whether they include waterbodies and, (3) what kind of microtopes (microtopography) they prevailingly include. It is possible to represent all these components on a two-dimensional simple scheme (Fig. 1) that gives us at once also a key for naming the mesotopes, i.e. the bog structures of higher hierarchical levels. The bog mesotopes (complexes, massifs) differ mainly by their surface form (concave, flat, convex) and by the regularity of microtopes location in the direction from the mire centre towards the mire margin. Therefore, the type of a bog mesotope could be characterized with an average percentage of areas of different microtopes, and the mesotopes could be named according to the dominating microtopes. The less prominent components (e.g. those covering less than 10% of the considered area) could be skipped in the names. Establishing of microtopes proportion constituting the mesotope will give us, moreover, information about the developmental stage of the bogs, so as the pattern of bog mesotope surface depends on the age and inclination. ELINA (1971) has established that hummock-hollow complexes will develop by inclination of bog surface 0.0005–0.006%. With increasing the bog surface inclination from 0.001 to 0.005%, the percentage of ridges increases from 20 to 80 and the percentage of hollows correspondingly decreases; in concordance with that the vegetation will change as well. For example, a *Sphagnum–Eriophorum–Scheuchzeria*-community will develop usually only in a case when the per cent of ridges is less than 50 and bog surface inclination less than 0.003% (ROMANOVA 1961). This physiognomic–structural principle of raised bogs classification is convenient and easy to use for carthographic purposes, or for the analysis of aerophotos as well.

It should be mentioned also, that if a certain structural component covers a remarkably larger area than the conventional scale limits mentioned above, it would be treated as a component of the next higher hierarchical level. Rather often, e.g. a comparatively large raised bog (mesotope), having for example an area of approximately 10^6 m^2, can consist only of hummock-hollow microtopes, and then the mesotope type will be named in the same manner as the microtope type (Fig. 1).

The regular distribution of mosaicness is inherent for some types of minerotrophic mires (e.g. aapa-mires) too, and so the principles discussed above could be, at least to some extent, useful also for classification of mires in a broader sense.

V. Certain synthesis of the approaches discussed above can be achieved using the concept of a hierarchical habitat site type classification where the topography, soil, water regime, trophic conditions and also species composition of communities are all considered (PAAL 1997, MASING et al.

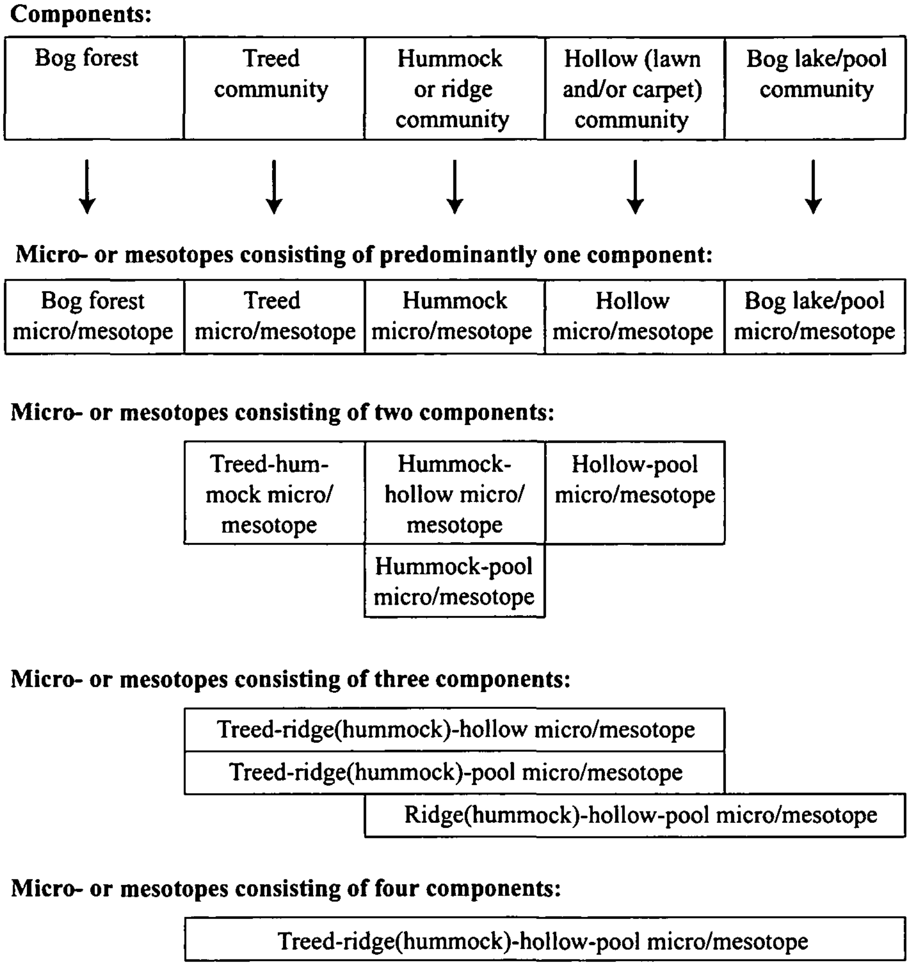

Fig. 1: Components of raised bogs – forested/treed bog communities, usually characteristic for bog margin, and typical bog expanse communities connected with particular nanotopes – forming in dependency of spatial scale microtopes and/or mesotopes. Modified after MASING (1982, 1984).

Photo 9: Hummock subtype ombrotrophic bog. Alam-Pedja Nature Reserve.

2000). The mire habitat site types are distinguished by prevailing trophic conditions and by genesis (heath moors versus raised bogs) of mires, the site subtypes are differentiated further by hydrological and landscape peculiarities (eutrophic fens), by development stage and topographical features (quaking fens and bogs) or by microtopes (resp. mesotopes) characteristics (raised bogs), while the plant community types are estimated by their dominanting species, being in mire plant cover almost always the indicator species as well.

Photo 10: Ridge-hollow subtype ombrotrophic bog. Tolkuse bog, Pärnumaa district.

Among the Estonian mires five habitat site types and 11 subtypes have been established (Tab. 3; PAAL 2001). The evaluation of species richness of site types in Tab. 3 is derived mostly indirectly from published data, since they have been collected for other purposes and are not dealing specifically with problems of diversity.

For better international communication the plant community names in Tab. 3 are given in Latin following the pattern of the international code of phytosociological nomenclature (BARKMAN et al. 1986).

However, since only some groups of communities in Estonia have so far been investigated and classified on the basis of the Zürich–Montpellier phytosociological methodology, the communities referred to do not always correspond to those in Central European vegetation classification systems.

Distribution of mires

Mires occur all across the country (Fig. 2). The average thickness of the peat deposit is 3.2 m (VALK 1988), while the maximum depth recorded is up to 18 m (PUNNING et al. 1995). Minerotrophic fens are the most widespread, occupying 515.000 ha or 57% of the total mire area. Mixotrophic (transitional) mires are represented on 114.000 ha (12%) and bogs on 278.000 ha (31%) (TRUU et al. 1964). There are altogether 1,626 peatlands with an area over 10 ha and

Photo 11: Ridge-hollow-pool subtype ombrotrophic bog. Männikjärve bog, Endla Nature Reserve.

Tab. 3: Typological diversity and species richness of Estonian mires. Species richness intervals (number of vascular plant species, *Bryales* and *Sphagnales* in 4 m²): * < 15, ** 15–30, *** > 30. Human impact classes: W – without direct human impact, F – former human impact (e. g. drainage, fire), P – permanent human impact (e.g. hay making, grazing), S – strong human impact (e. g. intensive drainage, forest plantation). In parenthesis a synonymous name is presented, in brackets is a possible attribute of the name.

Type group	Site type	Site subtype	Main communities	Species richness	Human impact
Eutrophic to meso-eutrophic minero-trophic) fens	Eutrophic fen		Primulo–Seslerietum Caricetum davallianae Schoeno–Drepanocladetum Caricetum appropiquatae–cespitosae Carici paniceae–Seslerietum Molinietum caeruleae Cladietum marisci Caricetum hostianae Caricetum buxbaumii Schoenetum nigricantis	** (***)	W (F, P)
	Floodplain fen		Calamagrostietum strictae Caricetum distichae Polygono–Circietum Caricetum acutae Caricetum vesicario-rostratae Carici paniceae–Seslerietum Caricetum diandro–nigrae Caricetum appropinquato–cespitosae Caricetum elatae Drepanocalado–Caricetum lasiocarpae Phragmitetum australis Phragmiteo–Schoenoplectetum	**	F (W)
	Spring fen		Carici lasiocarpae–Eriophoretum Caricetum davallianae Caricetum diandrae Scorpidio–Schoenetum	* (**)	W
Meso-eutrophic fen			Geranio palustris–Filipenduletum Caricetum appropinquatae–cespitosae Caricetum vesicariae–rostratae Caricetum acutiformis Caricetum elatae Eriophoretum angustifolii Caricetum paniceae–nigrae Drepanoclado–Caricetum lasiocarpae Calamagrostetum canescentis	* (**)	W, F
Meso-eutrophic quaking fen			Scorpidio–Schoenetum Phragmitetum australis Equisetetum fluviatilis	* (**)	W
Mesotrophic (mixotrophic) bogs-	[Wooded] meso trophicbog		Sphagno–Trichophoretum alpini Sphagno–Caricetum lasiocarpae Sphagno–Caricetum rostratae Sphagno–Eriophoretum vaginati Sphagno–Trichophoretum cespitosae Sphagno–Caricetum limosae	*(**)	W
		Mesotrophic quaking bog	Scorpidio–Caricetum lasiocarpae Caricetum diandrae Cariceto limosae–Menyanthetum	* (**)	W
Oligotrophic (ombrotrophic) bogs	Heath moor		Calluno–[Sphagno]–Pinetum Ledo–[Sphagno]–Pinetum	*	F, P, S
Raised bog	[Wooded] hummock	bog	Calluno–Cladinetum Calluno–Sphagnetum fusci Eriophoro–Sphagnetum fusci Trichophoro–Sphagnetum fusci Calluno–Sphagnetum magellanici	*	W, F, P

Tab. 3 coninued

Type group	Site type	Site subtype	Main communities	Species richness	Human impact
		Hollow bog	Rhynchosporo–Sphagnetum cuspidatum Rhynchosporo– Spagnetum baltici Scheuchzerio–Sphagnetum cuspidatum Sphagno baltici–rubelluetum Sphagnetum majus	*	W
		[Wooded] hollow-ridge bog	the same communities as in two previous subtypes		
		Pool bog	Nupharo–Nympahaetum Sphagnetum cuspidatum	*	W
	[Wooded] pool-ridge bog		*same communities as in previous subtypes*		
	Hollow-pool bog		same communities as in previous subtypes		
	[Wooded] hollow-pool-ridge bog		same communities as in previous subtypes		

Photo 12: *Carex lasiocarpa* dominated fen. Soomaa National Park.

Photo 13: odplain fen (meadow) area in early spring. Alam-Pedja Nature Reserve.

peat layer more than 0.9 m thick (ORRU 1997), 143 mires extend over more than 1.000 ha (PAAL et al. 1998).

In the distribution of these numerous mires, certain regularities can be observed, first of all in regard to the features of landscape topography. Species-rich fens are mainly found on the calcareous sub-surface on Saaremaa Island and in the western coastal part of the mainland.

The Primulo–Seslerietum communities are typical in areas with thin peat deposits (up to 1 m). In communities of this type the number of vascular plant species may exceed 130. Communities with a rather restricted distribution, such as Caricetum hostianae, Caricetum buxbaumii and Schoenetum nigricantis are also found in the same region but the species richness may be less (not more than 100 species of vasculars). The Drepanoclado–Schoenetum ferruginei communities, with *Salix rosmarinifolia* and *Myrica gale* in the bush layer, are mostly found in western Estonia, but they occur also in central Estonia. The Cladietum marisci communities may grow on calcareous seashores as well as in fens in the western part of Saaremaa Island; they occur also on the western coast of the mainland, where they can cover tens of hectares as in the Nehatu fen.

Poor fens are more common in the eastern part of the country. Characteristic are the communities dominated by sedges such as *Carex elata*, *C. lasiocarpa*, *C. appropinquata*, *C. vesicaria*, *C. rostrata*, *C. nigra*, while

C. panicea is more characteristic in the western, central and northeastern parts.

Floodplain (limnogenous) fens are most widely represented in the lowermost part of the western and southwestern Estonian river valleys as well as in the eastern and southeastern Estonia.

Spring fens are distributed rather sparsely over the country; they are mostly located on the marginal slopes of the Pandivere and Sakala Uplands and on Saaremaa Island. The water of these soligenous fens is usually calcium-rich and supports communities such as Schoenetum nigricantis, Scorpidio–Schoenetum, Juncetum subnodulosae (on Saaremaa Island), etc.

Communities of mixotrophic bogs with *Carex lasiocarpa*, *C. rostrata*, *C. limosa* are found mainly in western and central Estonia. They are rather scattered, except around lakes, where they are common. The Sphagno–Eriophoretum vaginati communities of the wooded mixotrophic bogs often form a belt around large ombrotrophic bogs, especially in northern Estonia (PAAL et al. 1998).

The larger bogs are located in the southwestern, northeastern and central parts of the Estonian mainland. The largest mire systems are Puhatu with 468 km^2, Epu-Kakerdi with 417 km^2, Lihula-Lavassaare with 383 km^2 and Sangla with 342 km^2 (ORRU 1995). Two regional types of ombrotrophic bog complexes are distinguished in Estonia – the "western" type and the "eastern" type (THOMSON 1924, MASING 1984). The marginal slopes of the western type have a steep rise. The bog expanse is relatively flat with an irregular pattern of compound microforms. The bogs of the eastern type are convex, with a well developed concentric pattern and without a steep slope. Eastern type bogs have favourable conditions for *Chamaedaphne calyculata*, which does not grow in western bogs. On the other hand, *Trichophorum cespitosum* and *Drosera intermedia* grow mainly in the bogs of the western type. Certain differences can also be found in the distribution of *Sphagnum* species: *S. fuscum* is characteristic for the eastern type raised bogs while *S. rubellum*, *S. imbricatum* and *S. tenellum* are more common in the West-Estonian bogs.

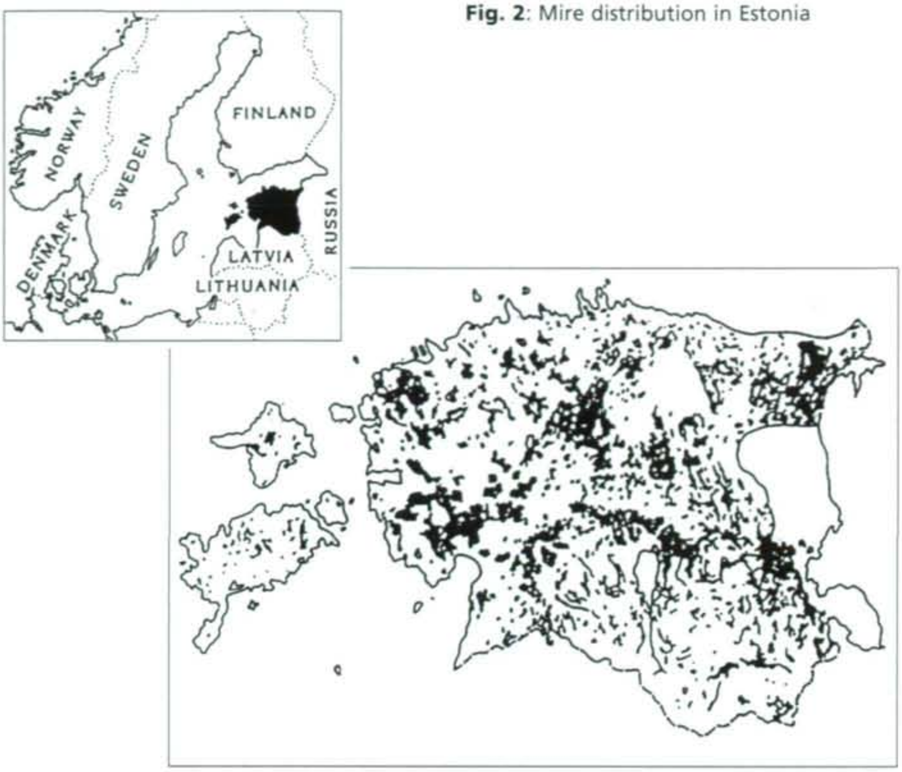

Fig. 2: Mire distribution in Estonia

Photo 14: Floodplain fen (meadow) area in early spring. Alam-Pedja Nature Reserve.

Heath moors, where thin peat (usually not more than 0.5 m) lies on pure sand, with an ortstein horizon between them obstructing water infiltration, occur in depressions between sandy dunes on the western coast and on the islands but also between old dunes located far from the recent coastline (PAAL 1997).

According to the distribution pattern of mires and their general features, Estonia can be divided into eight mire districts (LAASIMER 1965, ALLIKVEE & ILOMETS 1995; Fig. 3).

Photo 15: Floodplain fen (meadow) area in early spring. Alam-Pedja Nature Reserve.

Destroying of mire areas

Drainage for agriculture and forestry

In Estonia exploitation of mires for peat mining and agriculture started in the 17th century. At the beginning of the 19th century, drainage and burning of mires was commonly practiced for agricultural purposes (VALK 1988).

In 1839 the Estonian Agricultural Society was founded. One of its aims was to introduce and extend the drainage of mires. The first drainage system, where pipes made of burnt clay were used, was constructed as early as in the 1850's. In 1908, the Baltic Peatland Improvement Society was founded in Tartu, with the purpose of promoting and facilitating mire cultivation. In 1910, the Tooma Experimental Bog Station was opened, which specialized in the development of mire cultivation and the study of mire hydrometeorology.

From 1918 to 1940, more than 350.000 ha of peatlands were ameliorated, predominantly for agricultural purposes (RATT 1985), forest drainage accounted for perhaps less than 5% of this area (ILOMETS et al. 1995).

After 1947, there was a significant increase in mire drainage, as powerful machinery became available. In the 1950's, almost all undrained mires were bordered by ditches. This means that the hydrological regime of the marginal parts of the mire, mostly of minerotrophic ones, was damaged. In 1960–1970, open drainage was constructed in numerous fens with thin peat layer (about 1 m thick); this was frequently made by excavating one or a few ditches across the mire. As a result of that the hydrological regime and plant cover of the marginal parts of the mire was damaged. This kind of constructions were not regarded as the creation of a drainage system and therefore were not included in the official statistics. The marginal part of fens, accounting for some 20–25% of the total fen area, where the thickness of peat layer was less than 40 cm, was classified as peaty soil and was not considered by statistics as a "real" mire. Consequently, for getting an approximate figure for the extent of drained fens in that period, it may be more correct to double the officially announced area (ILOMETS et al. 1995, PAAL et al. 1998).

At the beginning of the 1970's the peat-covered area which belonged to the collective and state farms equaled 379.800 ha (KOKK & ROOMA 1974). During six years (1970–1975), 100.000 ha of peat soils were drained (HOMMIK 1982). In the 1970's, the annual drainage of wetlands for forestry purposes reached 15.000 – 20.000 ha (KOLLIST 1988). RATT (1985) reports that by 1980 about 1,006.300 ha of lands were ameliorated, including 338.400 ha of forests and 584.400 ha of agricultural lands. According

Photo 16: Ridge-hollow-pool subtype ombrotrophic bog. Männikjärve bog, Endla Nature Reserve.

to the summary of VALK (1988), as much as 897.400 ha of land had been drained for agricultural purposes, 604.800 ha of that by means of pipe drainage. About 120.000 ha or 20% had the fen peat thicker than 40 cm.

Comparison of the distribution area of different mires in 1955 and in 1990 (Tab. 4) proves that nearly natural conditions (in at least 2/3 part of a mire) were still preserved in some 200 mires covering a total area of about 310.000 ha (ILOMETS 1994b, ILOMETS & KALLAS 1995). Based on the data and the speculations presented above, it has been concluded (ILOMETS et al. 1995, ILOMETS & KALLAS 1995) that about 70% of Estonian peatlands are drained or influenced by drainage to an extent, which does not allow peat accumulation any more. The area of untouched or virgin mires in Estonia can hardly be more than 300.000 ha. The most endangered mire types are the minerotrophic mires, especially spring fens, species-rich calcareous fens and transitional (mixotrophic) bog forest sites. Of these, less than 10% are still in a more or less natural state from the hydrological point of view. The state of ombrotrophic bogs is somewhat better, mainly due to nature conservation efforts in the 1970's – 60–65% of raised bog sites may hitherto be in an untouched or natural state (ILOMETS 1994a, PAAL et al. 1998). It should be mentioned here, that LOOPMANN (1994) has disputed these estimations: according to his calculations, the area of drained mires has changed not very much during the period 1975-1995 and the proportion of mires in natural state can constitutes 71%. Still, as LOOPMANN admits, his calculations are based on the official data of the Statistical Department and the marginal parts of mires where the peat layer thickness is less than 0.3 m in drained grasslands and 0.5 m in drained forests have not been taken into consideration.

Peat mining

Peat is one of the most important natural resources for Estonia: the total peat resources are estimated at 2.57×10^9 tons, of which economically exploitable reserve constitutes 1.52×10^9 tons (ORRU 1995). Estonia has a long experience of using peat for heating purposes. Coordination of investi-

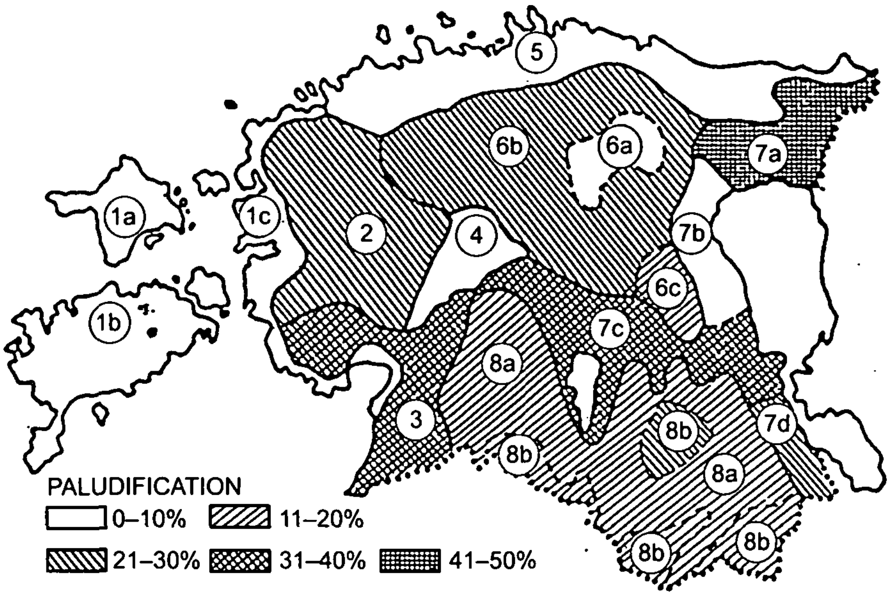

Fig. 3: The mire districts of Estonia. (after LAASIMER 1965). 1 – West Estonian small and middle size fens; subdistricts: a) Hiiumaa, b) Saaremaa, c) western coast. 2 – West Estonian middle size and large mires. 3 – South-West Estonian large bogs. 4 – Central Estonian small bogs. 5 – North Estonian Plain small and middle size mires. 6 – North Estonian large mosaic mires; subdistricts: a) central part (Pandivere Upland), b) marginal part, c) Vooremaa. 7 – Central and East Estonian large mires; subdistricts: a) northern part of Lake Peipsi depression, b) north-western part of Lake Peipsi depression, c) depression of Lake Võrtsjärv and delta of Emajõgi River, d) southern part of Lake Peipsi depression. 8 – Small mires of South Estonian uplands; subdistricts: a) valleys of uplands, b) moraine hill areas.

Tab. 4: Distribution of different types of Estonian mire sites in 1955 and 1990 (after ILOMETS et al. 1995) and the main factors causing their decline.

Mire type	**Approximate area**		**Impact factor**
	in 1955	**in 1990**	
1. Minerotrophic Mire Sites	650.000	58.000	
1.1. Soligenous mires	1.500	400	surroundig areas drained
1.2. Topogenous mires	334.200	40.000	
1.2.1. Rich fens	74.900	7.000	mostly drainage for agriculture
1.2.2. Poor fens	152.300	30.000	drainage for forestry and agriculture
1.2.3. Wooded swamps	10.700	3.000	drainage for forestry
1.3. Limnogenous mires	84.300	2.500	
1.3.1. Quakemires	1.300	1.300	
1.3.2. Flood plain fens	83.000	1.000	mostly drainage for agriculture
1.3.3. Wooded swamps on mobile groundwater sites	500	50	drainage for forestry
1.4. Topo-ombrogenous and limno-ombrogenous transitional mires	230.000	18.000	
1.4.1. Transitional bog	76.200	10.000	partly drainage for agriculture
1.4.2. Wooded transitional bog	151.800	8.000	mostly drainage for forestry
2. Ombrotrophic Mire Sites	383.000	250.000	
2.1. Heath moors	3.000	1.500	mostly drainage for forestry
2.2. Raised bogs	380.000	250.000	
2.2.1. Bog margins	80.000	60.000	drainage for forestry, industry
2.2.2. Bog centres	170.000	125.000	industry
2.2.3. Bog forests	130.000	65.000	drainage for forestry
Total	**1,033.800**	**310.000**	

Photo 17: Milled peat excavation area. Sangla bog, Tartumaa district.

gations and economical usage of peat in the Baltic countries was already one of the purposes of the Livonian Nonprofit Economical Society (Livländische Gemeinnützige und Ökonomische Sozietät), founded in 1772 in Riga (Latvia) and settled at 1813 in Tartu (Estonia). In the middle of the 19th century more than 300 pits of hand-cut peat were registered. These were located mostly on the lands of former estates (ANIMÄGI 1995).

At the beginning of the 20th century, the use of peat as fuel and as a means of producing electricity increased remarkably, as in the 1920's peat served as the main fuel for power stations; in 1926 it provided 10% of the total amount of industrial fuel (ILOMETS et al. 1995). In 1922, in order to organize and coordinate peat excavation, the State Peat Industry Enterprise was founded, uniting the biggest peat excavating entrepreneurs; smaller peat excavating companies joined into local societies, the total number of them being 916 in 1939 (ANIMÄGI 1995).

In several local industries the use of peat as fuel increased considerably after World War II. Peat excavation units associated with factories, amounting to 20 in number, were put into operation. In 1959, a new complex of the briquette factory was completed in Tootsi, with an annual output of about 420.000 tons. Later, two other factories were built – in 1964 the Oru peat briquette factory with an annual production of 250.000 tons, and in 1975 the Sangla factory with an annual output of 50.000 tons. Thus, preconditions were created for briquette production with a full capacity of 420.000 tons. The maximum output of 340.000 tons was achieved in 1976, but since the beginning of 1990's the factories have been working at a reduced capacity (Tab. 5; PAAL et al. 1998).

Milled peat excavation was initiated in Estonia in 1938. The output of milled peat started to increase rapidly in 1950–1960 on the basis of new products, horticultural and litter peat. In 1975, milled peat made up 98.6% of the total amount of peat excavated annually. The production of litter peat increased in the 1960's, when local agricultural associations were established in districts and excavation of peat became financed from the state budget. In 1975, there were 96 fields from which as much as 1,264.000 tons (40% humidity) of litter peat were excavated. That kind of peat exploitation has presently decreased remarkably (in 1994 only 345.300 tons) and the peat-fields are only partly used. In 1990, excavation of block peat was started for horticultural needs, and formed some 4% of the total annual peat output (ANIMÄGI 1995).

According to RAMST (1995) the production area exploited in 1970–1990 was 10.000–15.000 ha. The yearly production reached about 2.5×10^6 t (with 40% water content). The production of litter moss accounted for about half of it, that of milled peat for heating the other half. Since 1990 the production rapidly decreased because the demand for peat dwindled. The production was minimal in 1993 when only 0.6×10^6 tons was produced (0.4×10^6 tons of fuel peat). In 1994 the production increased again up to 1.1×10^6 tons.

As the domestic use of milled peat is declining, excavation for export (mainly to the Netherlands, Germany, U.K., France, Sweden, Finland) has increased from

Tab. 5: Peat excavation in Estonia in 1980–1996 (after ILOMETS et al. 1995).

Year	10^3 tons	Year	10^3 tons	Year	10^3 tons
1980	2.430	1986	2.900	1992	1.360
1981	1.520	1987	2.500	1993	621
1982	2.700	1988	2.400	1994	1.053
1983	2.700	1989	3.600	1995	1.020
1984	2.100	1990	2.080	1996	1.124
1985	2.100	1991	1.800		

116.000 tons in 1993 to 400.000 tons in 1996 (PAAL et al. 1998, Tab. 5). This increasing trend continues as the high quality horticultural *Sphagnum* peat resources are very limited in western Europe (HAMMER 1998). In the recent years 90% of the horticultural peat production and 65% of the fuel peat is exported (ORRU 2003).

In Estonian subnatural minerotrophic fens and mixotrophic bogs the mean annual growth of (air-dry) peat is 0.8–1.2 tons and in ombrotrophic bogs 1.1–1.9 tons (ILOMETS 1994c), or about 0.5 x 10^6 tons in total (ILOMETS 2003). In the recent years the amount of annual peat excavation has been 1.2–1.5 x 10^6 tons that exceeds the peat growth two–three times (ILOMETS 2001).

Industry and pollution

Significant areas of valuable mires have been destroyed through excavation of oil shale in open-cast mines in north-eastern Estonia. In order to get to the oil shale layer the surface has to be removed. Due to this, about 2.000 ha of mires have been destroyed and an additional area of 100 ha will be destroyed annually (ILOMETS et al. 1995).

A special problem is the flue gas containing calcium-rich, alkaline compounds from the cement factory and power plants burning oil shale (kukersite) in north-eastern Estonia. The gas contains, in addition to Ca, several heavy metals such as As, Zn, Th, Hf, V, which accumulate in plant tissues and peat (PUNNING et al. 1987). About 200.000 ha of land in a 30 km radius around the power plants have been affected. It has been estimated that 30.000 tons of Ca are deposited in dust falling on this area, resulting in the disappearance of the *Sphagnum* carpet, which in turn has halted the peat forming process and increased the decomposition of organic matter in the bogs within 10-15 km of the pollution source (KAROFELD 1994, ILOMETS & KALLAS 1995). Still, the production and the emission of gases at the power plants has during the last five-six years been reduced considerably.

Peat mineralization and CO_2 emission

One of the most important parameters indicating the state and functional peculiarities of a mire ecosystem is peat increment (ILOMETS et al. 1995). If the mire is drained, the peat accumulation stops and an extensive denudation of the peat layer takes place in the process of peat thickening. According to TOMBERG (1970, 1992), who has monitored this process on drained fen sites for several decades, the rate of peat surface decomposition is about 1 to 3 mm per year. The annual loss of organic matter due to mineralization is 15–20 tons $ha^{-1}yr^{-1}$ during the first decade after drainage not depending on the manner of explotation (pasture, cropfield, grassland). Later, the rate of loss stabilizes at about 10–15 tons $ha^{-1}yr^{-1}$ on cropland and 5–10 tons $ha^{-1}yr^{-1}$ on grasslands. The leaching of nitrogen may amount to 150–250 kg N $ha^{-1}yr^{-1}$ and 100–200 kg N $ha^{-1}yr^{-1}$, respectively. On grasslands the drained peat layer subsidence will be 1 meter for the first 20 years, during a century 2 meters of peat layer will vanish. In drained forests the peat layer decreases 6–15 mm per year (PIKK 1997).

LOOPMANN (1994) has calculated that peat increment has ceased in Estonia at least on 383.000 ha drained agricultural land where potentially 4 x 10^6 m^3 of raw peat had been produced. By ILOMETS (2001, 2003) the peat loss on this area constitutes ca 2.56 x 10^6 tons per year due to mineralization. Even if the peat loss in drained forests is not taken into account, this figure is roughly five times bigger than of for peat increment.

Assuming that the mean annual value of

Photo 18: Milled peat field abandoned for eight years. Ilmatsalu bog, Tartumaa district.

organic matter mineralization is about 5–10 tons $ha^{-1}yr^{-1}$ and the average carbon content in peat constitutes 53%, the annual emission of CO_2-C only from ameliorated fen areas may reach the quantity 0.8–1.6 x 10^6 tons of CO_2-C. Comparing this emission range with the possible total annual carbon storing by peat accumulation (0.25–0.32 x 10^6 tons CO_2-C), it follows that the emission from drained fen sites alone is on the average four times higher than its total annual carbon accumulation. Adding the drained areas for forestry and industry purposes we may reckon with up to 8–10 times higher emissions. (ILOMETS et al. 1995). In any case, the total CO_2-C emission from our wetlands may be about 9.6 x 10^6 tons yr^{-1} with corresponding ca 4.0 x 10^6 tons CH_4-C emission only (PUNNING et al. 1995). Therefore it is not surprising if wetlands are considered to be as the second important carbon source after industry in Estonia.

Urban development

The expansion of built up areas influencing the state of mires is most actual in bigger towns, especially in the surroundings of Tallinn. In several places, holiday camps are built on paludified areas but this kind of impact on the mires is still comparatively unimportant.

Vegetation changes due to human impact

Amelioration of the floodplain mires started more widely in the 1920's and the 1930's with dredging and straightening of smaller rivers and rivulets. According to the geobotanical mapping carried out in 1930–1955, most of the floodplain areas had been turned into grasslands. In that time they covered 83.000 ha or 7.5% of the total area of semi-natural grasslands (LAASIMER 1965). The inventory of grasslands in the late 1970's (AUG & KOKK 1983) assessed the area of floodplain grasslands to be 27.584 ha, which comprises about 35% of that in the first half of the century. At present, floodplain grasslands (like other semi-natural vegetation types) are mostly abandoned and overgrowing with bushes or trees is widely in progress. The result is that communities of some types, e.g. Caricetum davallianae, become gradually rarer.

The fen flora and vegetation in western Estonia has been intensively studied in 1948-1955 and re-studied in 1991–1992. On this basis it is possible to characterize the main trends in the composition of flora during the last 35–40 years. According to TRASS (1994), four groups of species should be distinguished:

- species with unchanged frequency: *Juncus subnodulosus*, *Myrica gale*, *Rhinanthus osilinensis*, *Cladium mariscus*, and several common obligate telmatophytes such as *Comarum palustre*, *Peucedanum palustre*, *Carex lasiocarpa*, *C. elata* etc.,
- species with increased frequency: *Molinia caerulea*, *Deschampsia cespitosa*, *Carex nigra*, *C. panicea*, *C. canescens*, *Epipactis palustris*,
- species wit slightly declined frequency: *Tofieldia calyculata*, *Carex buxbaumii*, *C. hostiana*, *C. davalliana*, *C. heleonastes*, *Eriophorum gracile*, *Schoenus ferrugineus*, *Liparis loeselii*, *Malaxis paludosa*, *Drosera intermedia*, *Saussurea esthonica*, *Pedicularis sceptrum-carolinum*, *Utricularia minor*, *Equisetum variegatum*, *Euphorbia palustris*,
- species with frequency fallen to the critical limit: *Gymnodenia odoratissima*, *Selaginella selaginoides*, *Pinguicula alpina*, *Malaxis monophyllos*.

Notable changes had taken place also in vegetation, TRASS (1994) has established five change-groups:

- communities met on approximately as large an area and with the same frequency as 35–40 years ago: Phragmitetum australis, Drepanoclado–Caricetum lasiocarpae, Scorpidio–Caricetum lasiocarpae, Caricetum diandrae, Cladietum marici, Primulo–Seslerietum, Caricetum cespitoso–appropinquatae, Caricetum flavae, Caricetum acutae, Juncetum subnodulosi, Equisetetum fluviatilis,
- communities the area of which has diminished to some extent (mostly only for some hecatares on certain fen): Drepanoclado–Schoenetum, Caricetum hostianae, Caricetum dioicae, Caricetum elatae, Caricetum vesicariae, Schoenetum nigricantis, Eriophoretum polystachionis, Scorpidio–Schoenetum, Menyantheto–Caricetum limosae,

- communities the area of which has considerably decreased (for hundreds or even thousands hectares, or if the community type is rare, more than 50%): Caricetum davallianae, Caricetum buxbaumii, Calloso–Alnetum glutinosae, Filipendulo–Alnetum glutinosae,
- communities the area of which has somewhat increased (on some fens for tens or hundreds of hectares): Myrico–Schoenetum, Seslerio–Caricetum paniceae, Calamagrostietum canescentis, Caricetum paniceo–nigrae, Myrico–Betuletum pubescentis,
- communites the area of which has remarkably increased (for hundreds or thousands of hectars): Molinietum caerulea, Deschampsio–Caricetum paniceae, Caricoso–Betuletum pubescenti, Phragmitoso–Betuletum pubescentis.

The reason for the decrease of areas of the 13 community types is in the secondary successions, which replaced natural communities after amelioration. The increase of *Molinia caerulea* dominance on calcareous fens and swamps after drainage has been recorded also by ROOSALUSTE (1984).

After a long period of drainage when the upper layer of peat has been mineralized, the former mire forests converge into so-called 'decayed' types where the characteristic mire plants cover less than 20%. The oligotrophic mire forests form *Vaccinium myrtillus* drained peatland forest site type, while the meso-eutrophic and eutrophic mire forest converge into *Oxalis* drained forest peatland site type (LÕHMUS 1981, 1982). The small number of drained forest site types is motivated by the post-drainage successional convergency – species composition of plant communities of drained sites gradually becomes more similar (ZOBEL 1992).

On burned raised bogs the microforms are almost levelled, the uppermost peat layer becomes thicker, capillary raise of water is impeded, peat water-holding capacity as well as aeration will considerably decrease, the soil chemistry will change significantly – the ash contains quite a lot of mineral components what increase for some period the soil pH and trophicity. Still, these additional nutrients will be rather quickly carried away by water and the peat becomes even poorer for plant growth than before fire (MASING 1960). To the vegetation of the first successional stages after fires several non-mire species are characteristic, first of all *Chamaenerion angustifolium*, due to lack of competition also *Rubus chamaemorus* and *Rhynchospora alba* can grow abundantly in some localities.

After 4–5 years all the burned area will be covered by vegetation: instead of former *Pinus sylvestris*, tree layer is formed now by *Betula* spp., in field layer *Ledum palustre*, *Calluna vulgaris*, *Andromeda polifolia*, in some cases also *Vaccinium uliginosum* will dominate. Development of the bottom layer starts often several years later; the commonest species is there *Polytrichum strictum* associated with lichens such as *Cladonia squamosa*, *C. cenotea*, *C. cornuta*, *C. floerkeana*, *C. deformis*, *C. incrassata* etc. Rehabilitation of *Sphagnum*-carpet begins usually with growth of some patches of *S. acutifolium*, then also *S. magellanicum*, *S. fuscum* etc. will appear (MASING 1960, 1964, MASING & VALK 1968).

Then a long period of stabilization of vegetation structure follows. Into the field layer return *Oxycoccus* spp., *Empetrum nigrum* etc., in bottom layer the pioneer species will be replaced by *Sphagnum* spp. and partly by forest mosses like *Pleurozium schreberi*, *Hylocomium splendens* etc. A further development of plant cover depends largely on the formation of tree layer: if this remains scattered then the characteristic features of bog fires will be obvious for long years. The rehabilitation of burned bogs and recovery of pre-fire communities structure takes form 50 to 100 years (MASING 1964).

Rehabilitation of spoiled mire areas

Rehabilitation and reclamation of destroyed peat areas has become a serious problem not only in northern Europe (VASANDER et al. 2000, KORPELA 2002) but also in Canada and USA (MALTERER et al. 2002, ROCHEFORT & CAMPEAU 2002). Rehabilitation of spoiled mires is an ethical as well as aesthetical problem (LODE 1998).

If in 1996 the total area of peat fields under excavation was in Estonia approxi-

Photo 19: *Eriophorum vaginatum*, typically growing in transitional and raised bogs is revegetating abandoned peat excavations as a pioneer species.

mately 18.600 ha (RAMST 1997) then in 1998 the area of mires spoiled with peat excavation constituted 21.350 ha and in next two decades the area of exhausted peat fields will be doubled. According to the data of Statistical Department in the last decade in Estonia is recultivated 1.500 ha exhausted peat fields. Still, it is not clear what nestles behind these data: was there planted a forest, were some ditches simple filled up or something else (ILOMETS 2001).

The natural revegetation of abandoned peatlands does not have the attributes of natural bog vegetation. The natural plant cover on abandoned peat fields is developing extremely slowly and sometimes does not occur at all (SALONEN 1987, LAVOIE & ROCHEFORT 1996). Several decades of attempts to recultivate them by planting forest culture have resulted with any success either. In many places the forestation is almost hopeless due to high water level and/or due to a thick and little decomposed peat layer. Another alternative is to plant an energy coppice or to turn the area into a pond.

A very promising possibility for re-establishing of plant cover, stopping the carbon emission and turning the areas into economically useful ones is to establish plantations of domestic cranberry *Oxycoccus palustris*. The detailed methods for founding cranberry plantations were elaborated in the Nigula Nature Reserve as early as in the beginning 1970's (VILBASTE 1972, 1974). In the last 5–6 years about 4 ha of cranberry fields have been planted with Estonian varieties, the crop can be up to 10 tons ha^{-1} (PAAL et al. 2002).

About 10 years ago experiments were also started with the seedlings of *Vaccinium angustifolium* originating from Canada. They grow very well on exhausted milled peat areas and the first crop can be picked in the 4th year (STARAST et al. 2005). Up to now about 4 ha of blueberry plantations has been founded and the area is rather quickly increasing.

Cultivation of other acidophilous berry plants such as *Vaccinium vitis-idaea*, *Rubus arcticus*, *R. chamaemorus* and herbs like *Drosera* spp., *Ledum palustre* has also a good perspective (JAADLA 1994).

Sustainable usage of mires

Tourism and recreation

Estonian bogs possess quite important recreational potential and many local people visit bogs, especially during their summer holiday. As bogs are distributed rather evenly over the country, there has not been any significant negative impact to the bog wildlife up to now due to tourism. During the last decade in numerous big bogs special wooden paths have been constructed to ease crossing of the bog landscape and for several areas informational materials for tourists visiting the bogs have been published. Estonian tourist agencies include some mire areas in their tourism packages. Nevertheless, it can be said that mire tourism is still in a rather embryonic state, considering its perspectives and the vast mire areas.

Collection of berries and other natural products

At the beginning of the 1970's, the inventory of Estonian cranberry resources was organized. It was concluded that in Estonia there are not less than 70 mires covering

Photo 20: Abandoned milled peat area recultivated with planted *Oxycoccus palustris* for three years. Sapi-Lulli bog, Tartumaa district.

about 25.750 ha in total with a cranberry yield of over 50 kg ha^{-1} (RUUS 1975). The potential overall annual production may reach up to at least 5 million tons.

The mires with the best cranberry crops are located in Tartu and Ida-Viru districts, where approximately 70% of the potential resources can be found. Furthermore, two mires – Emajõe Suursoo (transitional) mire on ca 6.200 ha and Muraka bog on ca 5.000 ha – give about 50% of the annual yield of Estonian cranberries – 1.5 and 1.0 million tons respectively. In certain places, picking of cranberries is one of the extra income sources for the local people. According to the official data, the state purchase of cranberries during some years of the Soviet period in Estonia was ca 300–1.300 tons (Tab. 6).

Much less is known about the distribution and yields of cloudberry (*Rubus chamaemorus*) resources. Perhaps some 30–40 sites are of commercial interest. Cowberry (*Vaccinium vitis-idaea*) and bilberry (*Vaccinium myrtillus*) are also important as they are picked by local people and often bought up for the food industry.

During the recent years, interest in sundew (*Drosera* spp.) has been increased and representatives from the western pharmaceutical companies have approached the local institutions. Up to now, the amounts

Photo 21: Abandoned milled peat area recultivated with planted *Oxycoccus palustris* for five years. Sapi-Lulli bog, Tartumaa district.

Tab. 6: State purchases of cranberries during 1963-1975 in Estonia (after CHERKASOV et al. 1981).

Year	Tons	Year	Tons
1963	315–417	1970	870
1964	1.218	1971	1.305
1965	315–417	1972	657
1966	315–417	1973	918
1967	315–417	1974	717
1968	570–576	1975	199
1969	570–576		

Photo 22: Abandoned milled peat area recultivated with sowed *Oxycoccus palustris* in 1976. Mättaraba bog, Pärnumaa district.

Photo 23: Ridge-pool subtype ombrotrophic bog. Põltsamaa bog, Alam-Pedja Nature Reserve.

gathered are still small, but will increase in the nearest future. The collecting of *Drosera* species, which have disappeared in most of the western Europe, therefore, must be regulated, otherwise the impact on bogs could rise critically (ILOMETS 1994a).

Rare and threatened communities, conservation of mires

Rare and threatened communities

The EC Council directive 92/43/EEC of 21 May 1992 (EC 1992) on the conservation of natural habitats and of wild fauna and flora stresses the need for assessment at a national level of the relative importance of sites for each natural habitat type according to four criteria: (i) degree of representativity, (ii) extent of area, (iii) degree of conservation, and (iv) global assessment. These criteria overlap largely with the criteria most emphasized in the assessment of the conservation value of biotopes (MARGULES 1986): representativeness, diversity, rarity, naturalness, area and threat of interference. Proceeding from the biodiversity concept of plant communities protection, three components must be taken into account: rarity, level of threat and typicalness, each of which is a 'complex phenomenon' (JACKEL & POSCHLOD 1996). Quite often in nature conservation 'rare' is used more or less as a synonym for 'threatened', the latter being the main criterion for compilation of Red Data Books of Biotopes (e.g. BLAB et al. 1993, RIECKEN & SSYMANK 1993). The problem of discordant use of 'rarity' and 'threatenedness' in categorization of species is thoroughly discussed by MUNTON (1987) and GASTON (1994), usage of these concepts in assessment of plant communities is discussed by PAAL (1998a,b, 1999).

The inconsistent use of 'threatened' and 'vulnerable' in one sequence is also obvious. The latter is a term with a comparatively narrow meaning; it is a synonym for 'fragile', while 'threatened' can in some situations describe even comparatively stable and widespread community types or even type groups. This was the case, for example, with our wetlands in the period 1950–1979, when in the course of a campaign started by Soviet rulers huge areas were drained and several hitherto common mire vegetation types turned to be threatened.

In Estonia, following these ideas, rarity categories for plant community types are proposed without merging them with 'threatened' or 'vulnerable':

0 – Extinct or probably extinct. Communities that are no longer known to exist in the wild within the territory of the republic after repeated search,

1 – Very rare. Communities that are known in 1–5 localities with a total area less than 10 ha,

2 – Rare. Communities that occur in 6–15 localities with a total area less than 50 ha for woodlands or less than 100 for grasslands and mires,

3 – Fairly rare. Communities that are represented in 16–40 localities with a total area less than 300 ha,

4 – Approaching rare. Communities

* that are likely to move into the previous categories in 5–10 years if the casual factors continue to operate, or
* that are growing in a restricted number of habitats but about which there is insufficient information to decide which of the categories are appropriate; the localities must, consequently, be checked.

It should be pointed out that in comparison with our previous papers where the

plant communities rarity categories were discussed (PAAL 1998a,b), later ones, based on more basic data the criteria for categories 1, 2 and 3 were considerably weakened, fitting them better in with the reality (PAAL 1999).

By defining categories of threatened plant community types the concepts 'rare' and 'vulnerable' are in place, and the categories can be estimated as follows:

1 – Very threatened. Community types that are at very great risk of total disappearance at least due to one of following factors:

* total area of communities has decreased in course of 10 last years 75%,
* communities are substituted to the adverse causal factors continuation of which will probably decrease the total area in next 10 years up to 75%,
* due to the extremely fragmented occurrence, communities are obviously loosing the inherently characteristic features of structure (content of species, abundance proportions between species, layering, mosaicness etc.),
* communities belong to the rarity category 1.

2 – Threatened. Community types that are at great risk of total disappearance at least due to one of the following factors:

* total area of communities has decreased in the course of 10 last years 50%,
* communities are substituted to the adverse causal factors which continuation will probably decrease the total area in next 10 years up to 50%,
* fragmentation of these communities has in 10 last years increased up to three times,
* communities belong to the rarity category 2 or 3.

3 – Fairly threatened. Communities that are in considerable danger due to the one of following factors:

* total area of communities has decreased in the course of 10 last years 25%,
* communities are substituted to the adverse causal factors which continuation will probably decrease the total area in next 10 years up to 25%,
* fragmentation of these communities has in 10 last years increased twofold,
* to this category should be qualified also communities being in Estonia rather frequent and having here not a very restricted area, but which are rare or greatly endangered in neighbouring countries, i.e. responsibility communities.

Tab. 7: Threatened mire communities in Estonia. R – category of rarity, T – category of threatenedness (cf. PAAL 1998a, 2001). Notations: Est. – Estonia, Isl. – Island. Nomenclature of the site types and communities follows PAAL (1997).

Site type	Community	Distribution	R	T
Poor fens	Caricetum flavae	locally, mainly in E Estonia	4	3
Rich fens	Caricetum davallianae	mainly on western islands, in mainland; scattered on northern limit of its areal	4	3
	Caricetum hostianae	in W and NW Estonia, seldom in other localitites; near the northeastern limit of its areal	3	2
	Caricetum buxbaumii	in W Estonia	3	2
	Cladietum marisci	mainly on western islands, locally on mainland; on northern limit of its areal	3	2
	Schoenetum nigricantis	in western part of Saaremaa Isl. and on Hiiumaa Isl.; on northern limit of its areal	2	2
	Rhynchosporetum fuscae	in NW Estonia	1	1
	Primulo–Seslerietum	mainly in W, N and NE Estonia, on western islands	4	3
Minerotrophic quagmires	Scorpidio–Schoenetum ferruginei	in W Estonia and on western islands	3	2
Spring fens	Scorpidio–Schoenetum ferruginei	in W Estonia and western islands	3	2
	Juncetum subnodulosae	in western part o f Saaremaa Island; on northeastern limit of its areal	1	1
	Caricetum davallianae	mainly on western islands, locally on mainland; on northern limit of its areal	3	2

Due to their species richness the most conspicuous mires in Estonia, on a North European scale, are calcareous fens and spring fens (TRASS 1975). Here grow numerous Red Data Book species such as *Selaginella selaginoides*, *Pinguicula alpina*, *Juncus subnodulosus*, *Liparis loeselii*, *Gymnadenia odoratissima*, *Dactylorhiza incarnata*, *D. fuchsii*, *D. maculata*, *Epipactis palustris*, *Cladium mariscus* and *Schoenus nigricans*. Several fen types more widely distributed in western and central Europe reach the northern distribution limit in Estonia (Tab. 7).

Over the last 30–35 years fens on shallow peat, formely mown annually and then grazed, have become extensively overgrown with bushes (mainly *Salix* spp. and birch). Spring fens, where they are still preserved,

are not usually threatened by scrub, but by the possible destruction of their catchment area.

Mire conservation

ILOMETS (1994a) has distinguished four periods in Estonian mire conservation:

1920 to 1940. Mire conservation was catalyzed by the need to protect birds; the idea of protecting mires for their intrinsic value was not a matter of discussion at all as a large number of mires was still intact. The need for nature protection in mires was first identified by palynologist P.W.THOMSON in his presentation in the Estonian Naturalists Society in 1923. Still, the first mire area, Ratva bog (1,109 ha), was taken under protection only in 1938, mainly to protect the Golden Eagle (*Aquila chrysaetos*) nesting there.

1940 to 1955. A lethargic period with extensive mire drainage. The concept of "improving nature" became the official policy in the whole Soviet Union where now the occupied Estonia belonged and each year about 45.000 ha of mires were drained for agriculture and 20.000 for forestry (VALK 1988).

1955 to 1968. A renaissance, with mire conservation driven by the need to protect both birds and plant species. The Nature Protection Act was passed in 1957 by the Estonian Supreme Soviet, among others the Matsalu Bay (including floodplain mires), Nigula bog and Viidumäe spring fen were declared state nature reserves; Muraka bog, Nehatu Cladietum marisci fen, and Nätsi bog were taken under protection as botanical-zoological reserves etc.

1968 to 1992. An active, successful period of significant achievements. In 1968, the "Telma" project was initiated to specify more accurately the criteria for mire protection areas. An active discussion between the scientists and ameliorators started in 1968 in the nature monthly "Eesti Loodus" and this resolved some of the mire protection issues. The mires more important from the water management aspect and the richest areas in berries were excluded from the land drainage programme. Thus 30 new mire protection areas were created. Among others, the most important mires of the present-day Soomaa National Park and Endla Nature Reserve got their protected status. Hence the surface area of officially protected mires rose to 15% of the total mire surface area in Estonia (ILOMETS 1994a). In the 1960's–1970's, District Governments established also hundreds of protected areas of "local importance"; some of these contain wetlands. Mires are also represented in the Lahemaa National Park established in 1971, in the Vilsandi National Park (established in 1971 as a nature reserve), in some geological and landscape reserves etc. In 1990's two large protected areas rich in wetlands – Soomaa National Park (370 km^2) and Alam-Pedja Nature Reserve (260 km^2) – were founded.

It seems rational to add a fifth period now, starting in 1992, when Estonia had re-established its political independence. After that Estonia has joined a number of international conventions, whereby it has made commitments to protect areas, objects or functions of biodiversity and environmental quality value. The Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat was ratified by Estonia on April 21, 1993; the Berne Convention on the Protection of European Wildlife and Natural Habitats came into force in Estonia on August 31, 1993; the Rio de Janeiro Convention on Biological Diversity was ratified by the Riigikogu (Estonian Parliament) on May 11, 1994 etc.

Considerable efforts have been made to establish a regulatory framework of environmental laws and policies. Estonia has officially, by signing and ratifying the Europe Agreement (1995), declared its political will to harmonize its national legislation to that of the EU.

The Act on Protected Natural Objects of June 1994 is the most relevant act for habitat protection. In the act and in relevant regulations, lists of species of the protection categories I, II and III are given. According to the amended Act on Protected Nature Objects (of February 1998), management plans are to be developed for all national parks and nature reserves.

Land Amelioration Law, approved in 1994, provides the legal regulations apply-

ing to land amelioration. It states that the building of amelioration systems (AS) can be started only after the project has been approved and building permission granted. The project of AS can be rejected and permission for building the AS refused in cases where the building of the AS would damage conditions for nature protection, or bring about economic loss for other landowners or users of the land and water. The project of AS must prescribe nature protection measures as well as the preservation of natural resources, the environment and historical objects.

The Sustainable Development Act (1995) defines inter alia the "critical reserve of renewable natural resources" as the smallest quantity, which guarantees the natural balance and renewal of biological and landscape diversity. One of its primary goals is to promote sustainable use of nature resources that are historically part of Estonia.

The National Environmental Strategy was approved by the parliament on March 12th, 1997. This strategy specifies the trends and priority goals of environmental management and protection, and sets the main short-term and long-term tasks to be achieved by 2000 and 2010, respectively. The National Environmental Strategy proceeds from the main traditional goal of environmental protection – which is to provide people with a healthy environment and natural resources necessary to promote economic development without causing significant damage to nature, and to preserve the diversity of landscapes and biodiversity while taking into consideration the level of economic development. The priorities presented in the strategy are to be taken into account when planning environmental activities, developing international cooperation and allocating national funds.

Estonian Biodiversity Strategy and Action Plan was completed in 1999.

Considering the drastic changes in land-use practice in connection with the collapse of the collective farm system and the re-privatization of land from one side, and requirement for establishing an effective nature management planning and protection system from the other side, several large scale nature inventory projects have been carried out between 1993 and 2000 (PAAL 2003). From the standpoint of promotion the mires protection here the following projects should be mentioned: (1) WETSTONIA – Estonian Coastal and Floodplain Meadows, 1993–1996 (LEIBAK & LUTSAR 1996), (2) Estonian Biodivesity Country Study, 1996–1997 (PAAL 1997, KÜLVIK & TAMBETS 1998, KUKK 1999, KULL 1999), and (3) Estonian Wetlands Conservation and Management Strategy, 1997 (PAAL et al. 1998). Results of these inventories were largely used for Estonian Natura 2000 State Programme, approved by the Estonian Gouvernment for years 2000-2007 in July 25th, 2000. The general aim of the program is to establish the Estonian Natura 2000 network in accordance with the Bird Directive and Habitats Directive.

More than 100.000 ha of areas with mire vegetation are protected in Estonia by now, over 3/4 of which are ombrotrophic areas. For a long time, mire conservation policy in Estonia was essentially designed to protect large ombrotrophic mire systems and it was difficult to preserve fens due to their use as potential agricultural land, despite their high natural value and their high level of vulnerability (ILOMETS & KALLAS 1995, PAAL et al. 1998). The actual number of currently protected mires in Estonia is more than 90, their very recent number and/or area was not attainable for the author as

Photo 24: Ridge-hollow-pool subtype ombrotrophic bog. Männikjärve bog, Endla Nature Reserve.

they have been increasing in the course of the last decade step by step and the amendment of databases needs some time. The area of protected mires will certainly increase when the Natura 2000 project will be finished.

Actual problems

Overexploitation of peat resources. As it was said in 4.2, in the recent years 1.2–1.5 x 10^6 tons of peat has been harvested in Estonia annually. This figure is more than two times less than the annual peat production quota (2.78 x 10^6 tons), established by the Government of Estonia in 1996 according to the Sustainable Development Act, and so the firms excavating peat have a serious excuse to apply for additional excavation areas and for supplementary excavation licences. At the same time, we stress once more, that the Estonian unspoiled mires can produce annually about 0.5 x 10^6 tons of peat. In that way, the peat excavation exceeds the peat accumulation already now two-three times. Let's us hope that this scandalous situation is provisional and connected with some weakness of the state statistical databases and some discrepancies between the legislation and practice, and is not based on lobby of certain businessmen or on corruption. Anyway, the peat production quota must be corrected to ensure a sustainable management of resources but efforts must be made also for improving the statistical data about peat resources; if necessary, additional research work for that purpose must be undertaken. Quite doubtful is also the Estonian Government energy policy, treating the peat as a renewable bioresource and enhancing it usage for heating.

Commercial pressure. A serious problem is further commercial pressure and lobbywork of some western entrepreneurs in connection with the increasing need for horticultural peat in those countries but also in Japan. While in western European countries the industrial peat resources are almost exhausted and the remaining subnatural mires are under protection, the commercial orders for peat are addressed more and more to the eastern and northern European countries, consequently causing there a continuous and intensive pressure on pristine bogs (GAUDIG & JOOSTEN 2002). The lobby and avarice of businessmen and undertakers must be strongly restricted here by quotas, by persistence in following the juridical acts, as well as by common acceptance of the ideas and demands expressed in the document "Wise use and conservation of wetlands", addressed to the Council and the European Parliament (cf. http://europa.eu.int/comm/environment/nature/wetlands/wetlands_en. pdf).

Insufficient rehabilitation. In USA, under the federal and state regulations, peat producers must agree to compensate for wetland losses and the ultimate goal is to restore the wetland conditions that historically existed in a peat bog before drainage and peat harvesting (MALTERER et al. 2002). In Estonia even the simple reclamation or rehabilitation of spoiled peat areas is going very slowly, and so the spoiled areas are continuously large sources of CO_2 emission into atmosphere as well as destroying the aesthetics of landscapes.

Pollution. In Estonia in the recent years considerable efforts have been made to diminish the alkaline flue gas emission from the cement factory and power stations in northern and north-eastern regions. Nevertheless, pollution is continuing and the situation is far from satisfactory.

Fires. Fires occur in raised bogs and heath moors in spring and summer period rather frequently and pose a considerable threat for mire ecosystems.

Long-term drainage effects. Some serious effects of the former extensive drainage will appear only decades later. That concerns especially successional changes of mire vegetation structure due to lowering of the water table in the surrounding areas; even in protected mires the characteristic communities will be replaced by others, having a simple structure. In that way communities of several types as well as numerous plant and animal species turn to be threatened and rare.

Evolvement of protected mires network. Although raised bogs are comparatively well protected in Estonia within the existing nature reserves (KALLAS 1995, KÜLVIK 1996), several fens, likewise some

well-developed bog complexes or even bog systems in different parts of the country have unique features and should also be taken under protection. According to the HABITATS DIRECTIVE (1992), all Estonian mires represent the habitats of EU importance and so as Estonia has still large number of unprotected natural or subnatural mires, most of them should be included into Natura 2000 network; even if from the Estonian viewpoint mires of some types (e.g. raised bogs) are protected rather satisfactorily, the remaining mires deserve protection as our responsibility communities/habitats. Before the Estonian Natura 2000 State Programme started, nature protectionists saw in it a great and last possibility to take under protection what still is worth of protecting in our nature. Nevertheless, the planned Estonian contribution to the Natura 2000 network seems to be too much oriented on the already existing protected areas the future of which should be guaranteed anyhow. Sites corresponding to Natura 2000 criteria outside the currently protected areas are often not paid enough attention to, especially if they are situated on private lands. With such an attitude, Natura 2000 program is planned to be used mainly for achieving additional „quality labels" for the existing network of protected areas, and not so much to contribute to the pan-European network with valuable new sites.

Zusammenfassung

Moore in Estland – In Estland gibt es 1.626 Moore, die größer als 10 ha sind, 143 davon sogar größer als 1.000 ha. Moore sind im ganzen Land zu finden, wobei die artenreichen Niedermoorgebiete vorwiegend auf der Saaremaainsel und im Westteil Estlands zu finden sind, Übergangsmoore in West- und Zentralestland und Hochmoore in den südwestlichen, nordöstlichen und zentralen Landesteilen. Die Flora der Gefäßpflanzen der estnischen Moore umfasst 280 Arten, 230 davon findet man in den Niedermooren, 103 in den Übergangsmooren und 45 in Hochmooren. Die estnischen Moore werden in fünf Standortstypen mit insgesamt elf Untertypen gegliedert. Besonders auffällig wegen ihres Artenreichtums sind dabei die kalkreichen Niedermoore und Quellmoore.

Um 1980 waren etwa 1,006.300 ha Moorland melioriert und damit entwässert. Torf ist eine der wichtigsten natürlichen Ressourcen Estlands, der jährliche Torfabbau erreichte in den Jahren 1970 bis 1990 ungefähr 2,500.000 Tonnen (mit 40 % Wassergehalt). Gegenwärtig beträgt der Torfabbau 1,200.000 Tonnen, was zwischen dem Zwei- und Dreifachen der natürlichen Torfakkumulation ausmacht. Vergleicht man die aus dem Torfabbau resultierende jährliche CO_2-Kohlenstoffemission (0.8–1.6 x 10^6 t CO_2-C) mit der möglichen Kohlenstoffspeicherung im Zuge der Torfakkumulation (0.25–0.32 x 10^6 t CO_2-C), ist das Missverhältnis noch deutlicher: Alleine von den entwässerten Niedermooren wird durchschnittlich pro Jahr vier Mal so viel CO_2-C emittiert wie gebunden. Zählt man noch die Flächen dazu, die für forstliche und industrielle Zwecke entwässert werden, steigen die Emissionen auf des Acht- bis Zehnfache der jährlichen CO_2-C-Speicherung an.

Naturnahe Verhältnisse in wenigstens 2/3 der Moorfläche findet man nur noch in etwa 200 Mooren mit einer Gesamtfläche von 310.000 ha. Bis heute sind davon etwa 100.000 ha mit intakter Moorvegetation geschützt, etwa 2/3 davon sind Hochmoore. Die größten Herausforderungen für die nachhaltige Nutzung und den Schutz der estnischen Moore sind derzeit (1) übermäßige Ausbeutung der Torfvorräte, (2) zunehmender ökonomischer Druck, (3) ungenügende Regeneration zerstörter Gebiete, (4) Luftverunreinigung durch Industrieabgase, (5) Brände, (6) Langzeitfolgen der Entwässerungen in der Vergangenheit und (7) die Entwicklung eines Netzwerkes geschützter Moore.

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